



SPECIFICATION

SPECIFICATION FOR VACUUM EQUIPMENT DESIGN & FABRICATION

APPROVALS	DATE	REV	DCN NO.	BY	CHECK	DCC	DATE
AUTHOR:							
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**SPECIFICATION FOR VACUUM EQUIPMENT DESIGN & FABRICATION**ATTACHMENTS:

- | | |
|--|------------------|
| 1) Vacuum Component List | LIGO_E0900410-v2 |
| 2) <u>Buyer's Vacuum Component Outline Drawings:</u> | |
| • SPOOL A-16 | LIGO_D0900946-v3 |
| • SPOOL A-17 | LIGO_D0900947-v2 |
| • SPOOL A-18 | LIGO_D0900948-v2 |
| • Mid Station Spool X-X | LIGO_D0902630-v1 |
| • MC TUBE - MC-A | LIGO_D0902632-v5 |
| • MC TUBE (Pumped) – MC-B | LIGO_D0902631-v3 |
| • Ham Septum Plates | LIGO_D070107-v1 |
| • Right End Station Layout (Ref. Only) | LIGO_D0900928-v2 |
| 3) Buyer's Sample Design Dwg. Package | LIGO_D0902633-v1 |
| 4) <u>Buyer's Flange Design Drawings:</u> | |
| a. 44.25 IN. Flange –Grooved/Slotted (Ref. V0494060) | LIGO_D0900953-v1 |
| b. 44.63 IN. Flange – Flat Faced (Ref. V0494042) | LIGO_D0900963-v1 |
| c. 45.19 X 68.25 IN. Flange – Flat Faced (Ref. V0494058) | LIGO_D0900961-v1 |
| d. 45.19 x 80.0 IN. Flange – Flat Faced (Ref. V0494047) | LIGO_D0900954-v1 |
| e. 60.5 IN. Flange – Flat Faced (Ref. V0494097) | LIGO_D970409-v1 |
| f. 60.5 IN. Flange – Grooved / Slotted (Ref. V0494031) | LIGO_D961111-v1 |
| g. 72.25 IN. Flange – Grooved (Ref. V0494020) | LIGO_D961104-v1 |
| h. 84.25 IN. Flange – Grooved (Ref. V0494021) | LIGO_D961105-v1 |
| i. 84.25 IN. Flange – Flat Faced (Ref. V0494127) | LIGO_D0902724-v2 |
| j. 1 IN. Tie Rod Assembly (Ref. V0494124) | LIGO_D0902727-v1 |
| k. 1 ¼ IN. Tie Rod Assembly (Ref. V0494158) | LIGO_D0902728-v1 |
| l. 44.63 IN. Flange – Grooved/Slotted | LIGO_D1000188-v1 |
| 5) Specification for Stainless Steel Plate - | LIGO_E0900402-v1 |
| 6) Specification for Vacuum Component Cleaning - | LIGO_E0900403-v2 |
| 7) Specification for Vacuum Component Leak Checking - | LIGO_E0900404-v1 |
| 8) Specification for SS Flange Forgings - | LIGO_E0900405-v1 |
| 9) Annulus Piping Detail (REF. V049-4-061) - | LIGO_D0902635-v1 |
| 10) Specification for SS Rolling and Machining - | LIGO_E0900406-v1 |



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11) Specification for Vacuum Component Bake-Out -	LIGO_E0900407-v2
12) Shipping Cover Air Purification System Drawing –	LIGO_D0902636-v1
13) Specification for Welding Inspections -	LIGO_E0900408-v1
14) Specification for Black Light Inspections -	LIGO_E0900409-v1
15) Specification for Welding Repair -	LIGO_E0900428-v1
16) Specification for Raw Material Handling -	LIGO_E0900429-v1
17) Specification for Cleanliness Testing -	LIGO_E0900430-v1
18) Specification for O-Ring and Flange Installation -	LIGO_E0900431-v1
19) Specification for O-Ring Procurement (Reference Only)	LIGO_E960085-v2
20) Pictures of the LIGO Facility (Reference Only)	LIGO_G0901032-v1
21) Sample 60 inch Vacuum Test Cover (reference only) (Ref. V049-4-192)	LIGO_D0902729-v1
22) Specification for SS Bellows	LIGO_E0900439-v1
23) External Loads – Mid Station spool	LIGO_D0902687-v3

1.0 SCOPE

This specification covers the minimum requirements of the Engineering, Materials, Fabrication, Assembly, Inspection, Testing, and Preparation for Shipping and Shipment of vacuum components for the Advanced LIGO modification Of the LIGO Observatories. Any attachments are incorporated herein by reference and made a part of this specification.

The specified components as shown on the Vacuum Components List # LIGO_ E0900410-v2 (Att. 1) are part of the Advanced LIGO upgrade of the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO is operated by Caltech and the Massachusetts Institute of Technology (MIT) under an NSF grant and includes observatories located in the Hanford Reservation (near Richland, WA) and second facility in Livingston, LA.

The California Institute of Technology (Caltech) is the Buyer for these components. The Seller is the successful bidder who is awarded this contact.

The original LIGO installation took place in 1998 and 1999. The attached specifications and procedures were used in that installation and have proven to be a successful approach to providing a system that meets the vacuum and cleanliness requirements required for the LIGO scientific work. All O-Ring Flange designs presented herein are proven designs which were used successfully for the past 10 years.

It is the Seller responsibility to follows these requirements or to propose alternate procedures and specifications to meet the requirements. All alternate approaches must be approved by the Buyer before use. The O-ring sealing Flange designs (Both Flat Faced and Grooved Flanges) must be provided as detailed herein.

All O-rings will be supplied by the Buyer.

2.0 Schedule

The Seller shall develop a detailed schedule and submit it two weeks after contact award. A preliminary schedule shall be provided with the Sellers proposal.

The Vacuum Components shall be delivery in two lots as detailed in the schedule. The components required for each grouping are show on the Vacuum Component List – LIGO_ E0900410-v2 (Att. 1).

The following contract milestones are requirements for this contact and shall be incorporated into the Vendor’s schedule:

- | | | |
|----|---|---------------------------------|
| A. | Project Kickoff Meeting - | One week after contract Award |
| B. | Preliminary Design Review (PDR) - | XX weeks after contract Award |
| C. | Release to buy Long Lead Material - | After PDR Approval by the Buyer |
| D. | Final Design Review (FDR) - | XX weeks after contract Award |
| E. | Release for Fabrication - | After FDR Approval by the Buyer |
| E. | Delivery of the First Lot of Equipment - | At sites 1/11/2011 |
| F. | Delivery of the Second Lot of Equipment - | At Sites 3/3/2011 |

XX – PDR and FDR dates will be determined prior to contract award with the selected vendor.

3.0 CODES AND STANDARDS

The following codes and standards are requirements for the fabrication of the equipment covered by this specification:

A. American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code, 2007 Edition Through all published Addenda.

Section II	Material Specifications
	Part A, Ferrous
	Part B, Nonferrous
	Part C, Welding Rods, Electrodes and Filler Metals
Section VIII	Pressure Vessels, Division I & II (Stamp Not Required)
Section IX	Welding and Brazing Qualification

B. Institute for Environmental Science and Technology (IEST)

Std IEST-STD-CC1246D - Product Cleanliness Levels and Contamination Control Program
(Ref. www.iest.org)

C. Clean Air Standard

ISO 14644-1 – 1999 Cleanrooms and Associated Controlled Environments


Priority of Codes and Documents: 1) This Specification, 2) Referenced Coded and Standards, 3) Fabrication drawings. Any discrepancies between documents shall be brought to the attention of the Buyer for resolution.

4.0 DESIGN REQUIREMENTS

4.1 General Requirements

All Vacuum Components shall be designed to meet ASME Section VIII requirements. Components do not required Code Stamping or Code Inspections.

The Vacuum Component design and materials of construction shall be as shown on each Seller fabrication drawing. The Vacuum Components shall be fabricated and tested in accordance with drawings, standards, and specifications referred to or attached as part of this specification.

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When shown on the Buyer's Component Outline Drawings, the Seller's Component design shall include design of components legs, braces and anchor plates. The Seller shall provide anchor bolt loading forces so that the equipment anchors can be designed by Others. Component centerline to bottom of legs anchor plate dimensions shall be provided as shown on the Component outline drawings. It is intended to have the component leg slightly short to allow for final component alignment during installation using anchor bolts and grout.

The Vacuum Components covered by this specification are to be used in ultra-high vacuum service and require strict cleanliness and contamination prevention measures throughout the material handling, fabrication, testing and shipping process.

All components shall be delivered to the jobsite cleaned to IEST-STD-CC1246C – NVR LEVEL A/20 and Particulate Contamination Level PCL 100. All Components shall be protected during final cleaning and testing by portable cleanroom certified to ISO STD 14644-1 – Class 5 particle requirements (Hereafter referred to as Class 5) whenever they are open to the atmosphere. They shall also be visible clean on the external surfaces. Class 5 is equivalent to the superseded FED-STD_209E Class 100.

All components of this specification seal to adjacent components using a double O-ring groove flange sealing system. The annulus space between the orings is pumped by a special dedicated vacuum pump to prevent leakage (actual pump supplied by others). One flange has a smooth face and the mating flange contains dual O-rings and a pump-out annulus groove. An annulus pump-out port shall be provided on each "O-ring Grooved" Flange per drawing LIGO_D0902635-v1 (Att. 9).

The buyer will provide the flange design and machining drawings (See flange fabrication drawings in Attachment 4). Vacuum Flange surfaces and bolt locations shall be fabricated as shown on the Buyers design drawings so as to properly mate with existing equipment. The seller is responsible for the shell to flange weld design and the overall component design.

All material storage and fabrication for these vacuum components shall be done in isolated areas away from other fabrication (plastic room or equal) to prevent contamination from smoke, dust and oily vapors from other manufacturing areas. The LIGO area shall be purged with clean air to prevent contamination from adjacent areas.

Stainless steel fixtures (spiders, roundup rings, etc.) shall be used as required to maintain vessel and nozzle roundness during fabrication. Carbon steel is not allowed to come in contact with the SS components or materials.

The Sellers Test covers shall have the following minimum ports: 1) RGA: Size: **TBD** 2) Pumpout: Size: **TBD**

All components shall have lifting lugs designed for safe and balanced lifting.

All bellows shall have complete Tie-Rod Assemblies to protect the bellows during individual testing and to allow safe installation at the job-site. (See Attachments 4j & 4k)

Component MC-B (Mode Cleaner Tube) will have 4 different viewport arrangements (Same size and number but different locations). This and all other viewport locations will be finalized at the FDR Meeting.

All components shall be designed to weigh less than 10,000 LB. (including all shipping doors, filters, etc.). This is required because of site crane limitations.

All vacuum components shall be designed and fabricated per the Seller's Quality Control Plan.

4.2 Mechanical Loading Requirements


In addition to general vacuum loading, the Vacuum Components shall be designed and fabricated to withstand the following additional loading:

- A. Spool MC-B Each of the 16.5 inch ports (2 total) shall be designed to hold 2000 Lb. of load on the flange (large Ion Pump and SS Gate Valve).
- Other Loading: Vacuum and Seismic loads shall be calculated by the Seller and integrated into the design of the component.
- B. Mid Station Spool The Mid station Spool shall be designed for the external Seismic Loads shown on Drawing LIGO **D0902687-v3** (Attachment 23) in addition to the Vacuum loads.
- C. All Other Components The Seller shall design the components for all applicable vacuum and Seismic loads.

5.0 DOCUMENTATION REQUIREMENTS

The Seller shall provide the following minimum Documentation:

- 1) All Vacuum Component designs shall be documented by detailed design packages similar to that provided by the Buyer in Attachment 3. (Typical Spool Drawing Package)
- 2) All drawings and calculations shall be reviewed, STAMPED and signed by a Registered Professional Structural Engineer Licensed in one of the 50 United States.
- 3) Certified Material Test Reports (CMTR's) shall be provided for all raw SS material used for spools (i.e. SS Plate, SS Flange Forging, SS Heads, etc.)
- 4) The Kickoff meeting, the Preliminary (PDR) and the Final Design Reviews (FDR) shall be documented by formal meeting notes with a corrective action list. Any Buyer/Seller formal conference calls shall be documented by phone notes distributed to all parties.
- 5) Vacuum Component Test Reports shall be assembled and sent to the Buyer when each shipment is sent to the job sites (Via overnight mail shipment / Not with the equipment).
- 6) The Seller shall prepare detailed procedures for all technical activities (i. e. Leak Checking, Bakeout, Cleaning, etc.) and submit them to the Buyer prior to the FDR meeting. All procedures must be approved by the Buyer prior to use.

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6.0 KICKOFF AND DESIGN REVIEW MEETINGS

6.1 Kickoff Meeting:

The seller shall conduct a Kickoff Meeting at the Seller's facility one week after project award. The Kickoff Meeting will be used to meet the Seller's key project personnel, to discuss project requirements in detail and to develop the near term project schedule.

6.2 Preliminary Design Review (PDR):

The Seller shall conduct a Preliminary Design Review per the schedule detailed in Section 2.0 at the WA LIGO Facility. The Seller shall present all details of their Preliminary Design and prove to the Buyer that it's justified to release Long Lead Materials for purchased. The Seller shall also tour the WA LIGO Facility to become familiar with the existing LIGO equipment and to view existing conditions at the locations of where the new Vacuum Components will be installed (By Others).

In addition to presenting the preliminary Vacuum Components designs and calculations at the PDR, the Seller shall also present their Quality Control Plan (including a detailed Contamination Control Plan), a detailed project schedule and a list of Long -Lead material required to be purchased after the PDR to maintain the project schedule.

Once the Sellers Preliminary design is approved by the Buyer, Long Lead Materials (SS Plate, SS Flange Forgings, Etc.) may be purchased by the Seller.

6.3 Final Design Review (FDR):

The Seller shall conduct a Final Design Review at their facility prior to releasing any components for machining or fabrication. All Vacuum Components Designs and all Cleaning, Testing, Inspection and Shipping Procedures shall be presented and approved by the Buyer before manufacturing can begin.

Fabrication aids (Fixtures, Round-up Spiders, Cleanroom components or units, etc.) can be purchased and/or built without the Buyers approval provided they are in conformance to this specification.

7.0 MATERIALS

All materials and equipment (Vacuum Pumps, valves, hoses, fittings, etc.) used on this contract shall be purchased new and used only on this contract. This test equipment shall be turned over to the Buyer at the end of the contract.

Vacuum Boundary materials and equipment shall not be purchased until approved at the PDR.


All vacuum boundary shell material shall be Stainless Steel (SS) and meet the requirement of SA240 for both grades 304 and 304L. Vessel head and flange material shall be type 304L.

Stainless Steel (SS) Plate shall be purchased per specification LIGO-E0900402-v1 (Att. 5).

The SS Plate, SS Flange Forgings, bellows and other vacuum boundary SS must be manufactured and purchased in the United States.

SS bellows shall be purchased from Hyspan Precision Products, Chula Vista, CA (619/421-1702)

SS raw flange forgings shall be purchased per attached specification LIGO-E0900405-v1 (Att. 8).

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All Conflat Port connections shall be furnished with solid SS covers.

CMTRS must be provided for all material and traceability of all materials must be maintained.

Identification of the material shall be maintained through all manufacturing processes. All cutoff parts shall be marked with the heat number of the parent part as indicated below on the exterior surface only (not on the vacuum boundary). If material identity is lost, the plate shall be re-qualified by making all tests that were required by the material specification or as indicated in this specification at the seller's expense.

All parts shall be marked on outside surface only. Marking on interior boundary vacuum boundary surfaces is not allowed. The minimum marking is to be the heat/lot number. Marking the materials with marking fluids, die stamps, crayons, paints and/or electro-etching is not permitted. A vibratory tool with a minimum tip radius of .005" is acceptable for marking the outside only of the finished shell. All other marking methods must be approved by the purchaser prior to use.

Dye Penetrant or other chemical testing shall not be performed on the Vacuum Components.

8.0 ROLLING OF PLATE AND MACHINING

All Vacuum Component designs shall be approved by the buyer prior to the start of any fabrication or machining. (After FDR).

All rolling of SS plate and SS machining shall be done in conformance to Specification LIGO-E0900406-v1 (Att. 10).

9.0 FABRICATION

9.1 General

All Vacuum Component designs shall be approved by the Buyer prior to the start of any fabrication or machining. (After the FDR).

The Mechanical Design of the Vacuum Components (Lengths, I.D., number and size of ports, etc.) shall be as shown on the Buyer's Outline drawings contained in Attachment 2 of this specification. The Seller shall develop their own design and fabrication drawings incorporating all requirements of these drawings.

Vessels do not require ASME Code stamping or code inspection.

All vessels shall be furnished complete as shown on the Seller's drawings, with all required shipping covers, bolts, washers, nuts, etc.

Vacuum Components Fabrication tolerances shall conform to the follows:

<u>Component:</u>	Lengths:	+/- 0.125 inches
	Inner Diameter:	+/- 0.125 inches
	Main Flange to Flange Parallelism:	+/- 0.030 inches
	Main Flange Perpendicularity to Centerline:	+/- 0.030 inches
	Main Flange Installed Flatness:	+/- 0.030 inches

Flange Machining Tolerances shall be as specified on the Flange Design Drawings in Attachment 4

9.2 Cleanliness:

No grinding with abrasive wheels, cloth or stones is allowed on the internal vacuum surface unless specified in this specification. This material is intended for use in a high vacuum application. Hydrocarbon contamination shall be prevented. The material shall be wrapped and covered at all times when the material is not being worked on to minimize possible exposure to contaminants. The Vacuum Components shall be cleaned (per section 10) prior to testing. No iron, carbon steel or other contaminants (such as grease, oil or hydrocarbons) shall come in contact with the component interior or exterior surfaces during material handling, fabrication, assembly and testing.

Any accidental contamination shall be immediately cleaned with liquid CO2 Spray.

Raw Material shall be handled and protected per specification LIGO E0900429-v1 (Att. 16).

9.3 Welding:

All welding shall be performed in accordance with the applicable codes (Section 4.0) and The Seller's approved procedures for design and fabrication. All procedures must be approved by the Buyer before use. The Seller's welder qualification and welding procedure qualification shall meet the requirements of ASME Section IX. All weld joint preparation shall be done by tungsten carbide tooling if possible. If minor grinding is approved by the Buyer, it shall be done with new clean materials.

Vacuum boundary and attachment welds shall be made with the Plasma Arc process or a GTAW welding procedure per an approved Seller welding procedure. For Plasma Arc welding, shielding gas shall be a 75% Argon/25% Helium mixture, backing gas shall be 100% Argon and Plasma gas shall be 100% Argon. Hydrogen gas is not permitted.

External support structures may be welded using GMAW process. All attachments to the vessel shall be by plasma arc or GTAW.

All weld wire and weld joint preparation areas shall be cleaned with CO₂ scrubbing prior to welding per a Buyer approved procedure.

All penetrations in the chamber shall be continuously welded on the inside per drawing details. Internal weld surface to be smooth but **NOT GROUND**.

All welds at vacuum boundaries are to be vacuum tight with a helium leak rate equivalent to a total of 1 x 10⁻⁹ torr liters/sec/component. The Seller shall leak test all vessel welds with a helium mass spectrometer.

Backing strips or rings shall not be used.

Longitudinal seams shall be positioned as shown on detail drawings.

Sharp edges are to be removed from all carbon steel areas where external painting is to be applied.

Post Weld Heat Treatment - Not Required

All welding repairs shall be performed per specification LIGO E0900428-v1 (Att. 15)

10.0 SHOP TESTING

10.1 General:

Testing shall be executed per the Seller's Q.A. plan.

Any component failing the Final Component Acceptance Testing shall be repaired, re-cleaned and re-tested.

Tie-rods shall be installed and tightened whenever a bellows is under a vacuum.

Post-cleaning vacuum tests and bakeout shall be performed with dedicated pump sets, flanges, valves and other equipment, procured new from high-quality manufacturers. Such equipment will be dedicated solely to these tasks under the subject procurement; will be protected from contamination at all times; and will be furnished to LIGO in serviceable condition (consistent with specified use) at the completion of the contract.

All roughing vacuum pumps shall be OIL-FREE Scroll type. Vendor: (tbd) Model: (tbd)

Turbopumps shall be OIL-FREE Magnetically Levitated Turbo Pumps with a minimum speed at the inlet port shall be 1000 l/s for nitrogen.. Vendor: (Edwards) Model: (STP1003C)

Pumps for testing flange annulus seals shall be OIL-FREE Ion Pumps or Turbopumps rated at 50 l/s.

After Final Cleaning (per section 10.3) the Vacuum Component must be protected from particulate contamination by a Class 5 cleanroom.

All O-Rings (Viton-Baked) shall be supplied by the Buyer per LIGO Spec. – LIGO E960085-v2 (Att. 19).

All O-Rings and Flanges shall be installed per specification LIGO E0900431-v1 (Att. 18)

All gases used to back-fill evacuated clean components shall be ultra clean gas (Air or N2).

Vacuum Components must be fully inspected under both visible and ultraviolet light ("Black Light") prior to the initial leak tests after steam cleaning. Any gross contamination shall be removed prior to leak testing. All visual inspections shall be conducted per Buyer Specification E0900409-v1 (Att. 14).

The Vacuum Components shall be visually inspected again after the detergent cleaning of each component.

Vacuum Components may be bolted together during Leak Checking, Cleanliness Testing and Bakeout to facilitate efficient testing. Septum Plates may be used for vacuum test covers on 60.5 I.D. Ports. If used, they still need to be delivered to the Buyer in new usable condition.

Any Special Test Covers fabricated for vacuum testing by the Seller shall be delivered to the Buyer in usable condition with the final component delivery.

Anytime a component is open to the atmosphere, it must be protected by a Class 5 Cleanroom.

All parts and testing components (Flanges, Conflat gaskets, O-rings, Test covers, Shipping Covers, etc.) shall be cleaned to the standard as the Vacuum Components.

Shop Testing shall be accomplished in phases per the following plan:

- 1) PRELIMINARY CLEANING - Components shall be Steam Cleaned per the Sellers approved procedure.
- 2) LEAK TEST - Components shall be Leak Checked per this specification. All leaks shall be repairs until the component passes the maximum leakrate requirement.
- 3) DETERGENT CLEANING - Components shall be detergent cleaned, DI water rinsed and dried per this specification. All cleaning must be done in a Class 5 Clean area.
- 4) CLEANLINESS TESTING – After Detergent Cleaning, the Component must conform to IEST-STD-CC1246D criteria as detailed in this specification. At this stage, the Buyer may perform additional analysis of surface quality. If the Buyer determines that a component needs additional cleaning and testing, the Seller will be reimbursed for associated additional costs on a Time and Material Basis.
- 5) COMPONENT BAKEOUT - After surface cleanliness has been certified, components shall be Baked at 150°C while under vacuum per this specification.
- 6) RE-LEAK TEST - Components shall be Re-Leak Checked per this specification. If leaks are found greater than the specification allows, the leaks shall be repaired and the component shall go thru Step 1 thru 6 again until they pass all tests.
- 7) FINAL RELEASE / CERTIFICATION - On successful completion of steps 1 thru 6 and submittal of complete process and test documentation, the Buyer will perform a final inspection of each component at the Seller's facility prior to approving shipment.


Buyer certification is required before each component will be released for shipment.

10.2 LEAK TESTING

All components shall be leaked tested per a Buyer approved Leak Checking Procedure developed by the Seller. The requirements of the Buyer’s specification “Leak Checking ” LIGO_E0900404-v1 (Att. 7) shall be incorporated in the Seller’s procedure.

10.3 COMPONENT FINAL CLEANING

All components shall be Detergent Cleaned per a Buyer approved Cleaning Procedure developed by the Seller. The requirements of the Buyer’s specification for “Component Cleaning ” LIGO_E0900403-v1 (Att. 6) shall be incorporated in the Seller’s procedure. After cleaning, the component must be protected by a Class 5 Cleanroom environment (Portable Cleanrooms are acceptable) to prevent particulate contamination.

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10.4 COMPONENT CLEANLINESS TESTING

Prior to Bakeout all components shall be tested for cleanliness per a Buyer approved Cleanliness Testing Procedure developed by the Seller. The requirements of the Buyer’s specification for “Cleanliness Testing” LIGO_E0900430-v1 (Att. 17) shall be incorporated in the Seller’s procedure. Cleanliness Testing must be done in a Class 5 Cleanroom environment (Portable Cleanrooms are acceptable). Components which fail cleanliness testing shall be re-cleaned and re-tested until they pass.

The Seller shall notify the Buyer when a component or group of components have passed cleanliness testing. At this stage, the Buyer may elect to perform additional analytical sampling at the Seller’s facility. Samples may be analyzed using FTIR and other methods, in order to detect residues at concentrations invisible to nominal production testing.

For planning and scheduling purposes, Buyer sampling should be assumed to take 1-3 working days and analysis results should be expected 5-10 working days after sampling is completed, depending on the size and number of components tested.

Additional mitigation or re-cleaning, if any, required by the Buyer in direct response to these sample test results will be performed at the Buyer’s expense. Associated Seller costs will be reimbursed on a Time and Material Basis. Material Markups and Labor Rates for additional work shall be identified in the vendor’s proposal.

The Seller retains full responsibility for maintaining and preserving cleanliness of all Components in all phases of production and delivery.

10.5 COMPONENT BAKE-OUT

All components shall be baked to 150 degrees C. while under vacuum until clean.

All components shall be Baked per a Buyer approved Component Baking Procedure developed by the Seller. The requirements of the Buyer’s specification “Component Baking Requirements” LIGO_E0900407-v2 (Att. 11) shall be incorporated in the Seller’s procedure.

10.6 FINAL COMPONENT CERTIFICATION BY THE BUYER

The Buyer will schedule Final Inspection of each component or group of components after all required process and test documentation for those items has been submitted and verified complete. The Seller shall provide work space, lifting or material handling, and other support infrastructure as required for the Buyer to perform the Final Inspection at their facility. After First Article inspections, direct inspection may be waived in limited cases at the Buyer’s sole option. Buyer certification is required before releasing each component for shipment.

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All components shall be prepared for shipment per a Buyer approved Procedure developed by the Seller. The requirements of this section shall be incorporated in the Seller's procedure.

Aluminum Shipping Covers shall be used on all open component flanged connections. These covers shall be provided by the seller for protecting the connections from mechanical damage and preventing the entry of dirt into the equipment. The use of tape or plastic sheet alone as a shipping cover is not acceptable. One shipping cover on each component shall have an Air Purification system to protect the Vacuum Component during shipping and storage. (See Drawing LIGO_D0902636-v1 for typical components of the Purification system in Att. 12). All system shall include a water vapor adsorbing module, a charcoal adsorbing module and a Class 5 particulate filter just before the component connection port.

All small components shall be wrapped in Class 5 cleanroom material after cleaning operations have been completed to prevent contamination. (i.e. shipping cover). All large components must be protected with a Class 5 cleanroom whenever they are open to the atmosphere. All Components shall be purged with Class 5 Air and packed for shipment in a Clean 5 Cleanroom.

Finished flange surfaces must be covered and protected during all fabrication steps and during shipment to The Buyer.

12.0 PAINTING

Any Carbon Steel surfaces shall be painted using a procedure and color approved by the buyer.

13.0 STORAGE AND SHIPPING

Vacuum Components shall be stored Indoors in a dry location prior to shipping. All vacuum components shall be delivered F.O.B. jobsite as defined on the Vacuum Component List (Attachment 1).

14.0 INSPECTION AND QUALITY REQUIREMENTS

The Seller shall have a Quality Assurance Plan in effect at all times specifying inspection, testing and documentation procedures that will ensure that the equipment furnished under the specification will meet in all respects the requirements of this specification. The responsibility for inspection rests with Q.A. Department. The Q. A. Plan shall incorporate a detailed Contamination Control Plan for all aspects of the contract.

The Seller is to inspect all raw materials and store them indoors in a clean dry storage space after delivery.

All Vacuum Component Welding inspections shall be done in accordance with Buyer’s Specification LIGO_E0900408-v1 (Att. 13).

Vacuum Components must be fully inspected under both visible and ultraviolet light (“Black Light”) prior to the initial leak tests after steam cleaning. Any gross contamination shall be removed prior to leak testing. All visual inspections shall be conducted per Buyer Specification E0900409-v1 Spec. for Black Light Inspections (Att. 14)

The Vacuum Components shall be visually inspected again after the detergent cleaning of each component.

The Seller shall notify the buyer 5 Days before any critical inspections or testing will occur so they have an opportunity to witness the work. A Detailed inspection plan shall be developed at the PDR meeting.

15.0 NON-ESCORT PRIVILEGES AND INSPECTION RIGHT

Non-escort privileges for LIGO, Government and LIGO representatives to all areas of the facilities where the work is being performed shall be arranged. This will include access to all areas where material is being processed or stored.